THE 1985 JOHN ARTHUR WILSON MEMORIAL LECTURE

PRESENTED AT THE 81st ANNUAL MEETING OF THE AMERICAN LEATHER CHEMISTS ASSOCIATION

Introduction of the Lecturer

by

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The following is an excerpt from a letter John Arthur Wilson wrote in 1918. "The science of the tanner, built up through centuries of practice, is very different from the pure science of a modern university and, in general, tanners and professors live in a widely separated sphere, each seeing the weaknesses but failing to appreciate the real achievements of the other. This seems to have resulted in misunderstanding, and even opposition, on the part of some tanners to aligning the interests of the industry with those of the university and it can hardly be said that the professors have shown a more conciliatory spirit." John Arthur Wilson spent a lifetime merging the practice of tanning with the pure science of the university. The memorial lecture series, named in his honor, continues the efforts of the American Leather Chemists Association to promote the advancement of chemistry and other sciences, especially in regards to their application to problems confronting the leather industry.

Our lecturer today clearly appreciates the achievements of tanners and scientists. He has, indeed, been a leader in promoting understanding between the leather industry's applied science and pure research. He has participated in and directed research on leather processes reported in numerous research papers published in the Journal and elsewhere. He received the Alsop Award in recognition of his research. He has developed a cooperative agreement with the French Leather Research Center that, in part, provides for making the results of their extensive research efforts more readily available to U.S. tanners and has developed an agreement with the Tanners Council of America that provides for the use of his laboratory's extensive leather manufacturing pilot plant facilities by the Council in it's educational programs. He has served as a member of the ALCA Council and Chairman of the John Arthur Wilson Memorial Lecture Committee, the Alsop Award Committee and of the ALCA-ASTM Joint Committee on Leather. He is Chairman of the Committee on the New Uses of Collagen and has organized and chaired three symposia on that subject at ALCA Conventions. He is a member of the Editorial Board and the ALCA Research Liason Committee. Currently he serves as President-Elect of the American Leather Chemists Association.

Dr. Stephen Feairheller is Chief of the Animal Biomaterials Laboratory of the Eastern Regional Research Center of the U.S. Department of Agriculture. He received a BS degree in chemistry from Pennsylvania State University in 1960 and a PhD in organic chemistry from MIT in 1964.

On behalf of the Salem Oil and Grease Company, who established and sponsors this lecture series, and on behalf of the Selection Committee, comprised of William Dooley, Gary Hanson and myself, I present, with pleasure, Dr. Stephen Feairheller.

THE 1985 JOHN ARTHUR WILSON MEMORIAL LECTURE
THE NEXT MAJOR CHANGE IN LEATHER MANUFACTURING TECHNOLOGY — WHAT IS IT LIKELY TO BE AND HOW CLOSE ARE WE TO IT?

Introduction

It is, without a doubt, the highest honor I have ever received, and perhaps ever will receive, that I have been selected to present this year's John Arthur Wilson Memorial Lecture, the twenty sixth in the series. I thank Mr. Dooley and his committee for selecting me and I thank the Salem Oil and Grease Company for their generosity in making this very popular lecture series possible. I would also like to thank my co-workers at the Eastern Regional Research Center. Neither the leather research program at the Center nor I at this podium would be here were it not for their fine record of scientific achievement over the years. And I especially would like to single out one person amongst my co-workers for special thanks. Without her efforts the preparation of this lecture would not have been possible. Miss Maryann Taylor did all of the extensive literature searching in preparation for the lecture. I would also like to thank the Agricultural Research Service for supporting the leather research program at our Center and for making it possible for our staff to participate in the affairs of our Association. Finally, our special thanks to those of you who support our program at the Center.

Twenty-five John Arthur Wilson Memorial Lecturers of great stature have preceded me; several are here in the audience this morning. The subjects covered in these twenty-five lectures have ranged from basic studies of collagen (1,2) to the requirements upon leather in modern shoe manufacturing practices (3,4), from leather research in developing countries (5) to the needs for greater research efforts in developing countries (6-9), from hide and skin properties (10-12) to leather properties (13,14) to footwear properties (14,15). Many of the lecturers have been forward looking in their subject matter and it is my intention that this lecture will be too. In this year's lecture, I would like to explore with you the current state of technology and technological development of the leather manufacturing industry, using historical information as a background, and to develop from that some projections about upcoming major changes in technology which I feel are possible, even probable.

In the process of doing this, I will take the time to review some of the major research developments and current efforts of the various research centers around the world. In the past few years I have had the good fortune to be able to attend several international research meetings and to visit a number of these research centers. I have gained a lot from these experiences and have used the information in developing the lecture. If the lecture serves no other purpose, it will at least provide me the opportunity to review this research for you.

The lecture is divided into three parts; an arrangement which, to me at least, appears to be logical. The first part will be a discussion of what the most significant advances have been in

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leather manufacturing technology over the years. I propose to discuss these advances in a section entitled "Historical Developments." The second part will be a review of current and emerging research and technology developments and what these developments mean for the future under a section entitled "Current Technology." Finally, I plan to examine some of this emerging technology for its possible combination into a new technological breakthrough and to consider how close we are to realizing such an event in the concluding section which I have entitled "Conclusions."

Historical Developments

The two most significant changes that have occurred in leather manufacturing technology took place more or less hand in hand during the latter half of the last century. They are well over 100 years old at this time and it's obvious that both have aged very well. Neither is without some problems, but also, neither has, despite some healthy competition over the years, any really serious competitors. The first change was the movement of wet processing from open, stationary vessels - open pits or paddles - into closed, rotating vessels - drums. The second was chrome tanning.

The change from open pits, or even paddles, to rotating drums had a dramatic effect on processing in terms of the labor requirements and the speed and efficiency of the processing. In combination with the second change, the conversion of hides to tanned stock was measured in hours rather than days and today's efficient bluing operations were possible.

Based on years of experience in the work place, it certainly appears that the final choice of processing vessel for most tanners is the rotating drum. Other types of rotating vessels come and go but, for batch processing, this vessel appears to be the end of the line. Certainly evolutionary changes are occurring in drum design and capability all the time, and will continue to occur, but no revolutionary change in processing vessel has appeared on the horizon. This is in no way meant to imply that research on new types of tanning vessel is not going on, it is. And perhaps I will be proven wrong. That is a hazard with making predictions.

Trivalent chromium appears to have just as firm a hold on tanning as drums have on tanning vessels. Even though there are extensive research efforts under way at numerous research organizations around the world looking for alternatives, and despite the several problems associated with the use of chromium as a tanning agent, including potential supply problems and established or rapidly developing waste disposal problems, I don't feel that chromium is going to be replaced by anything else as the major tannage for most leathers. Almost every kind of leather known, for whatever end use, can be made from a primary chromium tannage. The major reason this has been accomplished is that in one easy step, hides and skins can be very effectively tanned to a high degree of thermal, especially hydrothermal, stability, higher than is really needed in some cases. This is because of the unique chemistry of chromium and the chemical structure of collagen that combine to provide for the effectiveness of the tannage. No other materials, metal or organic compounds, have been found that are able to achieve the same degree of tannage and I firmly believe that none ever will that will have the universality of chromium. This is not to say we should stop our research that is looking for them. A lot of very good information is being obtained from these research studies about the several different mechanisms of tannage, and useful alternatives are developing for specific applications. I'll return to this later.

There are several additional historical changes that, while not of the same magnitude as rotating drums and chrome tanning, need to be mentioned because of their bearing on the future.

The first of these is brine curing and the introduction of the pre-fleshed, brine-cured hide,

a development that is still a controversial issue. The subject will most likely be discussed at some length tomorrow morning as part of the Rawstock Committee Symposium. Curing of hides by a number of means, including with salt, had been practiced for a long time but the relatively rapid and, if done properly, very effective method of brine curing resulted in significant changes in the relationship between hide supplier and tanner as well as in the way the tanner processed the hides. It has also affected the economics of leather manufacture as well as its geographic distribution, both nationally and world wide (16). While I have not ranked it at the same level of importance as chrome-tanning and drum processing, it obviously has had an immense impact which in part has been negative. Brine curing adds a significant cost to the production of leather without adding to the value of the leather and it certainly is a heavy polluter. It also severely limits the potential non-leather uses of hide components, most importantly of the collagen. While brine curing might be considered an advance for some, I don't feel that it was for the tanner.

The second is the development of synthetic retanning and finishing agents and even fat liquors. I haven't ranked this development with chrome tanning and drum processing in importance either; I rather consider it as an inevitable evolutionary change from the natural materials to the synthetic materials as has occurred with many products. That is not to belittle the significance of it, however, for it has had its impact. Certainly, some important markets for leather would not have been possible without these materials. Also, improvements in methods of application and handling have significantly altered the labor requirements for these steps of leather manufacture. These are improvements that were not possible with many of the natural materials.

The third is the development of new machinery, a development that continues at a rapid pace even today. Some specific examples were provided in the symposium yesterday morning. These represent evolutionary improvements which have been driven by the desire to reduce the amount of hand labor. This they have done. The current state of development, still driven by the same desire, is of significance to the future and I will return to this later.

Current Technology

There is a considerable amount of research being carried out around the world for this industry. It presently appears to be decreasing in quantity; but, it is still significant. Certainly, the relative emphasis it is given in different countries is changing. Most of the research conducted over the last ten or more years has been driven by one need, the environmental need. This continues to be the case today and probably will into the foreseeable future. Implementation of the technology resulting from most of this research has simply added to the cost of making the leather; however, there have been examples where it has reduced the cost or even added to the value of the leather itself. It has not all been negative and some of the results have important implications for the future.

The most innovative of this new technology is continuous beaming. That which has been put into practice was developed in Darmstadt (17-19) and practiced now at two tanneries in Europe. In brief, the process consists of spraying unhairing chemicals onto hides, draped hair side out, over bars carried through the spray on a conveyor. The hides are then, in a relatively short time, carried through a specially designed unhairing machine which removes the loosened hair. They are then carried through a spray that halts the action of the unhairing chemicals, in effect it chemically destroys any residual unhairing chemicals. The hides are then removed from the conveyor and hand fed into fleshing and splitting machines. The process has been described to us in the past by its inventor, Professor E. Heidemann. Our Center developed a more ambitious continuous process (20-22) which has not yet been

adopted by industry. In contrast to the Darmstadt process, ours consists of loading the hides on bars on conveyors and lowering them into vats of the chemicals. They are then fed while still on the conveyor into unhairing and fleshing machines. Regardless of whether or not these two continuous beaming processes have yet been adopted, they have adequately demonstrated that certain wet processing steps traditionally carried out as batch operations can be carried out in a continuous fashion. They also demonstrated that certain associated machinery operations can be part of the continuous process. We attempted to include splitting as a part of the continuous process but to date have been unsuccessful.

Biotechnolgy is a very popular subject these days, a subject that means different things for different people. In my broad definition of what biotechnology is, the industry has been using it since the very beginning. Biotechnology, to me, is the application of biological processes to industrial processing. Therefore, bating falls under this definition as would any other process utilizing enzymes. Biotech purists don't agree with this broad definition; to some, molecular biology must be involved for qualification as biotechnology. Enzymes are biological catalysts that cause chemical reactions to take place easily and extraordinarily rapidly under conditions that are not normally optimum for the reactions. The conditions are usually quite mild because the enzymes themselves will not tolerate extremes. Up until now, the applications of biotechnology in tanning have been with rather crude preparations of enzymes. Laboratory exploration of the use of more highly refined preparations of specific enzymes have been conducted and these will be reviewed in a paper later today (23). With the advent of genetic engineering, the possibility of producing specific enzymes relatively cheaply and in large quantities for specific uses now exists. Scientists at our Center are attempting to transfer the genetic material responsible for the synthesis of an enzyme that catalyzes the selective hydrolysis of fatty acids from naturally occurring triglycerides from a fungus to a bacterium where it will hopefully be produced in large quantities as an extracellular enzyme. Similar efforts could be made with enzymes of interest to the tanning industry if they are needed. If leather manufacture is to continue as a series of batch processes there is a future for the use of enzymatically catalyzed reactions; if leather manufacture converts to a continuous operation there may be no future for them, they may be too slow. I qualify this because I can think of some possible applications for them, and I'll return to this subject later.

As I mentioned earlier, a large amount of effort has gone into, and continues to go into, a search for alternative tanning agents. The alternative that appears to be getting the most attention is the combination of aluminum salts and vegetable tannins (24). Other, somewhat related combinations are also being explored and some quantities of leather have been made using them. A wet white as an alternative to wet blue has been developed from this research (25-30) and this has led us at ERRC to consider other alternative intermediate marketable products. However, it appears to me that different combinations of some of these tanning materials must be used to make different leathers although this may not be the case with the combination that produces the wet white. In addition to the above, titanium tanning is the subject of a paper on this program from the Tanners Council Laboratory (31) and we at ERRC have explored a new organic tannage that may serve as a white, light stable pretannage. Both may have some application but I don't believe they will have the universality of chromium.

Two novel applications of chromium tanning methods need to be mentioned here. At Reutlingen, there has recently been experimentation on the injection of chromium tanning solution into suitably prepared hides by means of the type of injection guns that are now used to give medical injections (32). With suitably designed arrays of injection guns and the

proper chrome tanning agent and strength, adequately tanned products were prepared. This development has real, very significant implications for continuous processing. And, some years ago in Italy, research was conducted on the introduction of chromium tanning agents into undelimed hides and skins (33-36). A rapid, thorough tannage was achieved with complete float exhaustion and a final stock pH of about 3.5 to 4.0 The leather had a distinct character because the hide had been tanned in a swollen state. Further work might eliminate this problem but I don't believe it was pursued.

The application of radiation curing technology to leather finishing, as it has been explored over the last several years at our Center, is extremely important both now and for what it means for the future (37,38). It warrants your serious consideration. For the present, it offers almost total elimination of emission of volatile organic compounds from the evaporation of the solvents used with common finish formulations and significant energy savings because there is no need to evaporate either the organic solvent or water (from water based finishes). It saves space since the finishes are cured virtually instantaneously and thus do not require long conveyor systems and ovens; and the leather can be stacked immediately. What further needs to be done to bring it into use? As far as I can tell, the ball is now in the court of the chemical companies to provide the appropriate formulations for you to use. In addition to the finishes, our scientists have investigated the impregnation of full grain leather, using similar formulations to those used for finishing, followed by radiation initiated polymerization and the results are very encouraging (39,40). The problems of impregnating preformed polymeric impregnants into full grain leathers are overcome by the use of these polymer precursors and, of course, the technology is usable with other than full grain leather. The advantages given for finishes apply to this application as well and the improvements realized in leather break and scuff resistance are dramatic. For the future, the speed and automatability of radiation curing have important implications. This will be discussed in the last section.

There are several specific developments in the new machinery available to the tanning industry today that I would like to call to your attention. First, much of the new machinery has been developed as feed through machinery rather than feed in - feed out. This development has utility now in that it carries out the process in one direction and reduces labor requirements. It also has important implications for the future. The new drying equipment with automatic toggling devices, as well as other devices for stretching the leather out, are also of importance. The symposium yesterday that I already mentioned described some of these.

There are two additional, somewhat interdependent developments, that I want to discuss together. They are hide segmentation and non-leather uses of hide collagen. The former was proposed by USDA scientists and economists about 20 years ago (41,42) and got a cool reception. It was proposed at the same time that we started the non-leather uses of hide collagen studies with the demonstration that lime splits could be used as a raw material for reconstituted collagen sausage casings. At the same time, "Hippies" made blue split suede leather popular and we were accused of conducting research that was designed to disrupt a profitable part of the business. When those studies were initiated, blue splits were a drug on the market.

Our hide segmentation concept proposed the rather drastic trimming of hides to produce a rectangular section for leather manufacture with the trim destined for special leather or non leather uses. Our economists demonstrated how, at that time anyway, this was economically sound. In addition, it had implications for further leather manufacturing steps, and for shoe and other leather goods manufacturing as well, that were significant. The handling, whether manually or by machine, is many times easier when working with regularly shaped pieces.

Machinery design certainly is simpler. Processing time can be faster. Pattern cutting is easier. However, it never caught on.

The second part, non-leather uses, was limited to the sausage casings at the start and continued to be so for a number of years. That is changing rapidly. Cosmetics (43), biomedical devices (44), and pet treats (45) are established and rapidly growing non-leather areas of use. Development of food uses beyond the sausage casings will happen too. Much of the research to lay the ground work for these additional food uses has already been done (46). Some in the established processed meat industry will mount some effort to prevent the substitution of collagen for red meat protein in these products on the grounds of dilution of nutritional value. I believe that our research has shown that, within certain limits, this is not the case, and the real reason for this counter effort is concern over the use of less red meat. There may be some consumer acceptance problems too if its introduction is not handled properly. But looking on the positive side, or negative side depending on your point of view, substitution of just five to ten percent of the red meat protein with collagen in fast food hamburgers would consume a lot of hide material.

Finally, for this section, I should mention that automation of tannery operations is being integrated into many tanneries. The automation can be rather simple or quite complex. It can reduce labor requirements and the possibility of human error. Regardless of our personal feelings about computer control, it is playing a more important role in all parts of our lives, including our businesses and is now available for our use.

Conclusions

With all of the above in hand, and with the help of some additional information, it is possible to consider some breakthroughs that are already possible or that might be with little further work. I'll try to indicate what that further work is when we come to it.

Before I do that, however, it is necessary to consider other developments in the meat, hide, and leather industries and the implications these developments have for the future. A trend has started to develop in these industries that, if it continues, will result in a rather dramatic change in the leather industry. The change has been referred to as stratification (47-49). I believe it has already been demonstrated that it is sound practice to conduct wet processing -that carried out successfully thus far has been bluing - near the source of the hides and to avoid brine curing, or any kind of curing, completely. Two of the industries mentioned above have started doing this already, the meat industry and the leather industry. Some in the meat industry are on record that, at this point in time, the investment needed to get started in bluing is too great and for the near term they will remain suppliers of just brine cured hides and not of wet blue. I would guess, with the contraction that is going on presently in the tanning industry, there would not be too much interest in developing centralized bluing operations right now in that industry either. However, there is no doubt in my mind that the trend has started and it is likely to continue. It may not, and it certainly does not have to, continue with the development of bluing facilities, at least not as we know them now. There are alternatives which need to be considered and that is what I plan to conclude with.

There is certainly no question that, for most of the tanning industry, the economic situation is a bad one. At a time like this it is generally very difficult to get anyone overly excited about technical innovation, especially technical innovation that requires capital investment. However, I'll forge ahead and consider several of the above developments as they might influence technical innovation and also industry stratification. These developments are con-

tinuous beaming, alternative intermediate marketable products, hide segmentation, and non-leather uses of hide collagen. Some possible combinations of these developments exist that to me make a lot of sense as alternatives to current practices.

The first of these combinations that I'd like to propose includes continuous beaming and wet white or some other suitable partially processed product short of blue. Beaming by the Darmstadt or by our continuous process to the point of hair removal appears to be sound. Some improvements could probably be made and I feel that the use of the Darmstadt unhairing machine is superior to our method. Continuous processing from this point to the partially processed product has not been developed, even in the laboratory, as far as I am aware. There is technology that could be applied but a considerable amount of work needs yet to be done. Some technology that comes to mind is the injection technology explored at Reutlingen for chrome tanning. Perhaps this technology could be modified and further developed to accomplish the remaining steps to convert the partially processed product to an acceptable final product. Another possibility is that practiced already and generally known as the Secotan process (50). This process involved placing tanned stock on a perforated plate with a vacuum underneath and flooding the surface with a solution of the desired treating material, retannage or fatliquor, in acetone. A shroud was developed to prevent the loss of material from around the edges and as the acetone solution was pulled through by the vacuum, the retannage or fatliquor was deposited within the tanned stock. Of course, we now may have entered the field of solvent processing, a field which we may not want to enter. It does have the advantage that the product is dry and therefore weighs less; but, the necessity to control and recover the solvent is a problem. Perhaps the Secotan process could be adapted for use with aqueous solutions and/or application of the materials used to produce wet or dry white. As I said, a considerable amount of work needs to be done on this yet.

An alternative means worth considering for continuing on after continuous beaming is batch processing in highly automated drums or other vessels. This appears to be the route taken at Darmstadt for processing to the blue from their whole hide continuous beaming process (19,51).

One thing that must be considered here is that the research done to date on all of this has not, with the possible exception of that done by the Darmstadt group, developed a rapid, continuous process to replace the combined effects of liming and bating. The former achieves a chemical modification of collagen itself, as well as removal of certain noncollagenous material; the latter achieves the removal of other noncollagenous material. This all takes time and perhaps cannot be accomplished without extended batch processing after the continuous processing. Our scientists will be studying the physical chemical aspects of these processes in the near future and these studies might indicate how and when the necessary changes might be best accomplished.

Wet, or dry, white does not have to be the only partially processed product considered. Other alternative products exist. A traditional one is pickled stock. An extension of this to dried pickled stock is possible (52) and this reduces the amount of water that needs to be shipped by a considerable amount, if that is a concern. If a variation of the Secotan process is considered, perhaps a simple solvent dehydrated product would be the choice although if this process is practiced I suspect it would need to be used for more than just dehydration. Still a further alternative is the new organic tannage we developed recently at our Center that can be applied under slightly alkaline conditions (53). This would eliminate the pickling step or delay it until further processing needed to be done.

I am certain there are other alternatives that also can be considered but I think I need to go on with my discussion of possible combinations of technological developments. This first

combination involved processing of full thickness hides. By not including splitting I eliminated the need to consider when and how it would be done; but, at the same time, caused other steps to be more difficult. So, let's consider splitting. Engineers at our Center attempted to include splitting as the last step in the continuous beaming process. It was to be accomplished by feeding the hide into a specially modified splitting machine from an overhead conveyor. It turned out to be extremely difficult and was never completely successful. The Darmstadt group manually fed the hides through a splitting machine after the hides came off of the continuous beaming equipment and had been manually fed through a fleshing machine. These steps were very effective but required hand labor. In any case, and however it's done, splitting at this point has many advantages. The hide at this point is relatively clean and unadulterated with chemicals. It is free of tanning chemicals. The flesh split is therefore free to be used for various non-leather applications. Another advantage is that further processing need only be carried out on hide material of much less thickness. Operating conditions will be less difficult and savings in chemicals will be realized. This will be the case for all of those alternatives discussed above including the Reutlingen injection methodology, the Secotan process, and liming and bating.

The third combination I would like to propose is a further extension of the first and second together. It has two advantages. It achieves the optimum in raw material utilization and further simplifies the subsequent steps. It is hide segmentation and it needs to be applied just prior to splitting. The bellies and other pieces removed can be put to numerous uses and the resulting rectangular piece of hide should be much easier to handle in the splitting operation whether it is done manually or as part of a continuous process. Also, the subsequent steps, including application of the Secotan process, would be much easier to carry out and the savings in chemicals, not only in wet processing, would be significant. The waste associated with the disposal of unacceptable parts of the product would be considerably less, both in the tannery and in the end product manufacturing operation. The advantages of this need to be reconsidered in light of these new developments.

I have proposed the above as a means of producing a partially processed product short of blue with the implication, especially in view of my earlier comments about the universality of chromium tanning and its irreplaceability, that chromium tanning would be carried out on these products at some later time and in some other place. For some types of leather perhaps chromium tanning is not even necessary. But where it is for large quantities of leather, I actually don't think it makes that much difference where chromium tanning is done as long as all tanning, even pretanning, is done after segmenting and splitting. It is also important that it is carried out in a way that does not contaminate other solid wastes. That way, only the material destined to become leather is tanned and the disposal of chromium containing hide material and other solid wastes is not a problem. Although I don't know for certain, I have to believe that cutting shoe parts, for example, from a rectangular piece of hide would also result in less waste at the shoe manufacturing plant than is now the case.

So, where does all of this leave us for wet processing? I believe that the development of an integrated process to take hides from the packing house, without curing, and convert them into a wet white, or possibly and preferrably a dry white, deserves serious consideration. The hides would need to be soaked perhaps with the addition of materials, surfactants or enzymes, to at least start removal of noncollagenous components. Perhaps attention should be given to the development of specific enzymes or enzyme mixtures to complete the necessary changes normally accomplished in liming and bating at this point. During certain times of the year, special attention would have to be given to the removal of manure balls. Enzymes might also be helpful here. The hides could then go through the continuous unhairing,

fleshing and segmenting steps followed by splitting. Then appropriate treatments, perhaps batch treatments, would be necessary to produce dry white. However, serious consideration should be given to the various continuous processes for this too. The trim and the flesh splits would go to whatever end use was appropriate. Remember, they haven't been tanned and a number of options are possible. Splitting could be accomplished after the segmented hide was converted to wet white, especially if the flesh split were intended for leather use. This would make the process a much easier one in that control over splitting could be maintained based more easily on end product requirements.

While I have generally avoided discussion of waste treatment I will just mention here that for some types of waste products, more is not worse, it can be better. The greater the volume available of some of these materials, the easier it is to develop uses for them, a lesson that has already been learned by some in the industry. Large wet processing facilities have the "advantage" of producing large volumes of waste products, let's call them by-products, and some potential users are not interested unless they are available on a regular basis and in significant quantity.

This is probably as far as the centralized cattle hide processing operations should take a hide. The process could be made very efficient, including the by-product processing. The lack of contamination of the materials with chromium and the large volume available makes their uses in a variety of products possible. It should be mentioned here that other partially processed products should be considered too. Perhaps some with no tanning agents at all. What industry will it be that does this? I would hope that it would be the tanning industry; but, there is already interest being shown in the meat and hide industries, especially where they are part of the same company.

I'd like to shift my attention now to the remainder of the leather making process. I do believe without reservations that all of the remaining steps can be converted to a continuous process. By the remainder I mean conversion of the pretanned product, perhaps wet or dry white, into finished leather. And, if smaller lots of material, of the sizes now processed through retan-color-fatliquor, are involved, specialized tannages other than chrome tanning should be considered. These specialized tannages can be based on end product requirements. The parts of this where the most work needs to be done are in the tanning and dyeing. But, I think the type of technology utilized in the Secotan process might be adaptable for much of this as well as for retanning and fatliquoring.

Drying technology is advancing rapidly and combined with automatic toggling and/or dynamic stretching under vacuum along with mechanical working, a continuous operation may not be too far away. Certainly, the radiation curable impregnants and finishes make this part of the process seem to be achievable too. The speed with which these take place coupled with necessary intermediate operations could complete the process. In addition, radiation processing could lend itself to the development of new effects in finishing already practiced routinely on other substrates but now achieved by hand treatment, requiring some degree of artistry, for leather. As we all know, there are already contract finishers for leather and there are contract radiation finishers for other substrates. Perhaps, that is how this technology will get applied to leather, through contract.

Who will it be that buys the wet white and converts it to the finished leather? Could it be the leather goods manufacturer who then contracts to have those steps carried out? I don't know. I can imagine the continuation of the continuous process beyond leather finishing to computer assisted pattern cutting, especially if the leather is of a uniform, regular shape. This is all pretty much nothing more than conjecture at this point but, I firmly believe leather will eventually be made and used in this way.

Let me conclude by giving my answers to the questions I posed in the title - what is the next major technological change in leather manufacturing likely to be and how close are we to it? In answer to the first part, I think it's pretty obvious from what I have said that I feel the next change will be to at least a semi-continuous process or, perhaps, series of processes. And, I think they very well may look something like I have described above. One continuous process takes a well soaked and perhaps enzyme-modified and purified hide to a partially processed marketable product and a second produces finished leather from the product of the first. In answer to the second question, let me first say that I don't think the huge tanning drums currently in use in today's big automated tanning operations are likely to become the dinosaurs of an extinct tanning industry yet this decade, or even century. The biggest of these tanning operations, where the environmental impact is the greatest, are the places where the possibilities for alternative solutions are also greatest. At least some of these companies have invested in, and continue to invest in, the research necessary to provide solutions to the problems. These large operations have also automated their processes to a considerable extent. These investments will likely establish their positions for some time to come.

I'd like to pose and attempt to answer another question. What will be the driving force (or forces) for this change? They are not new. Environmental concerns are a major force. To a large extent, they were the driving force that initiated the research on continuous beaming and the other developments I have described. Those processes described above all produce less or no pollution or produce it in a more concentrated, more easily treated form. Another driving force is reduction in labor requirements. All of the developments had that in mind. Still another one is reduced energy requirements. While this is not as much of a concern now as it was a few years ago, it has not gone away. Two others are time and space requirements. The final one is better raw material utilization. These forces continue to be very much in the minds of those conducting research today around the world and alternative continuous processing schemes are being investigated. This is true in both industry supported research laboratories and non-industry supported research laboratories.

Someone once said that when a man's mind is stretched to accept a new idea it can never return to its original size. Leather researchers minds have been stretched to accept the concept of continuous processing in one form or another.

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